MEBT Absorber Prototype Status Update

Project X Meeting, 06-Nov-2012

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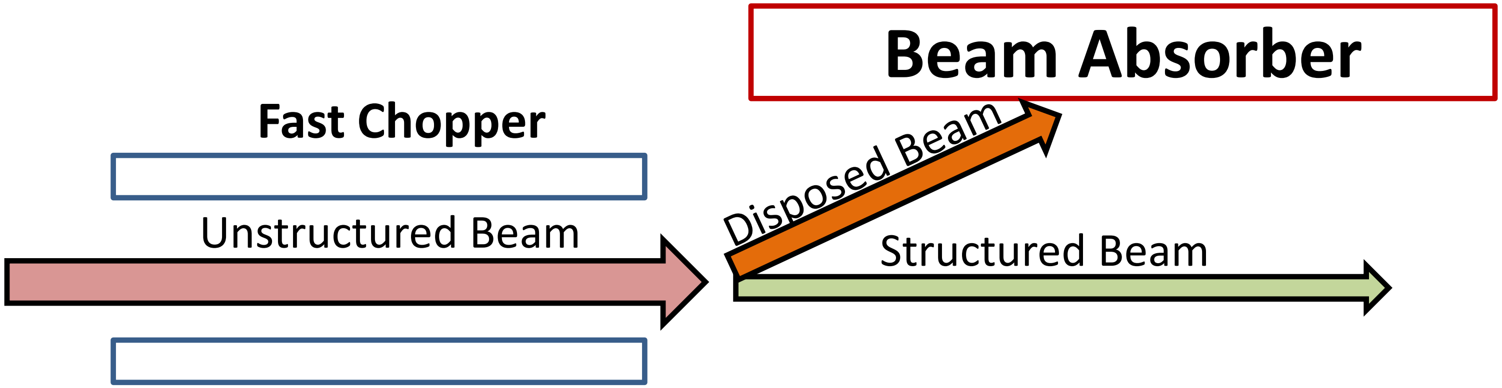
PX Doc DB ID: Project X-doc-1112

MEBT Prototype Absorber Update

- Background and Goals
- Prototype Fabrication
- Next Steps

Background: Absorber Configuration



Functional Specifications Document:

https://projectx-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=964

Key Driving Absorber Requirements

- 2.1MeV Ions
- 21kW maximum absorbed power
- Beam size: $\sigma_x = \sigma_y = 2$mm
- 650mm maximum length

Key Derived Parameters

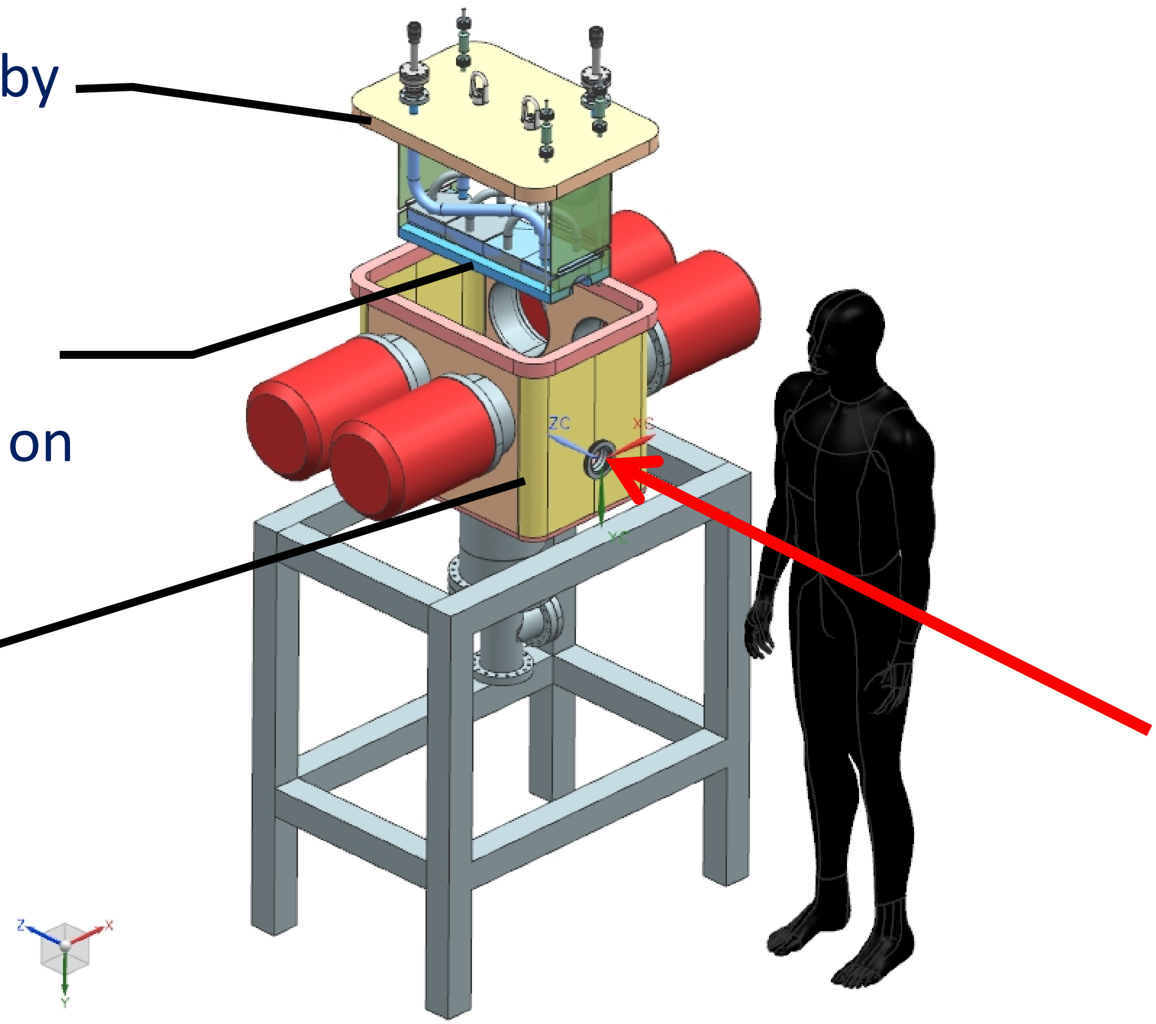
- 0.029rad grazing angle
- ~22 W/mm^2 maximum incident power density of the face of the absorber

MEBT Absorber Preliminary Concept

Absorber handled by this flange

Qty. 4 absorber modules mounted on common structure

Vacuum Enclosure



BEAM

Key Challenges

Challenge	Mitigation Approaches
Sputtering	Provide adequate erosion allowance in material, ~700um/beam-year expected.
Ion-induced blistering	Use blistering-resistant material
Thermal concerns: • High power density • High operating temp. • Temp-induced stress	Geometry: Grazing angle of incidence Material: High-temp Molybdenum TZM Cooling: mm-scale cooling channels
Secondary Particles	We have come to the realization that secondary/reflected particles will impose a significant heat load requiring active cooling

Design Risks

Key risks of this specific design include:

- Manufacturing processes
  - Machining of Mo TZM
  - TZM-to-stainless transition
- Flow characteristics and heat transfer
- High temperatures in absorber material
- Module-to-module and global alignment stability
- Blistering/Sputtering of TZM material in H- Beam

Addressed by prototype testing

Prototype Approach

- Prototype a single absorber module
  - 116mm length
  - Single-pass water cooling
- Test in existing E-beam gun
  - 30kV, 0.2A, ~6kW beam
  - Gun system is flexible enough to provide a range of beam conditions
- Angle of incidence between absorber and beam 120mrad
  - 4X greater (more normal) than PXIE plan
  - Allows us to replicate peak power deposition within limited length of test module

Goals of Prototype Testing

Project X

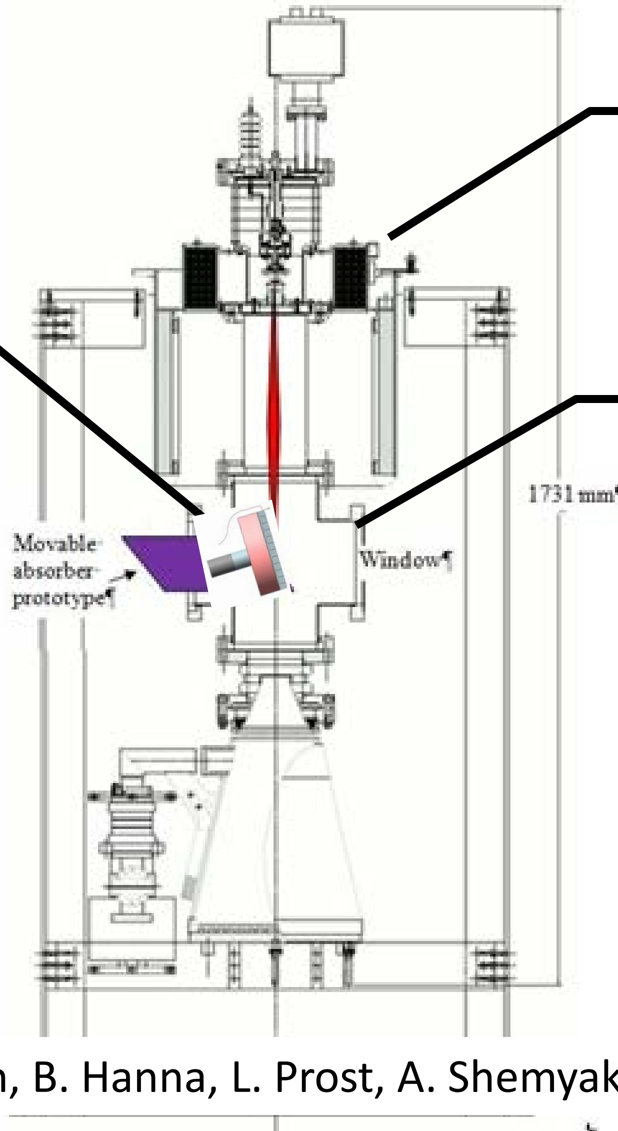
Goals

- Investigate areas of fabrication risk
- Correlate measured and predicted temperatures to improve modeling
- Investigate cooling performance in different flow regimes
- Test ability of absorber to survive expected power density
- Test ability of absorber to survive thermal cycling

Timeline

- Test bench commissioning proceeding, using a “pre-prototype” absorber – a solid Mo TZM block
- Barring a failure in fabrication/test, plan to install prototype absorber in test bench in December.
- All learning will be used to inform the next iteration of absorber design later in FY13.

Prototype Test



Electron gun, re-used from electron cooling program

Absorber

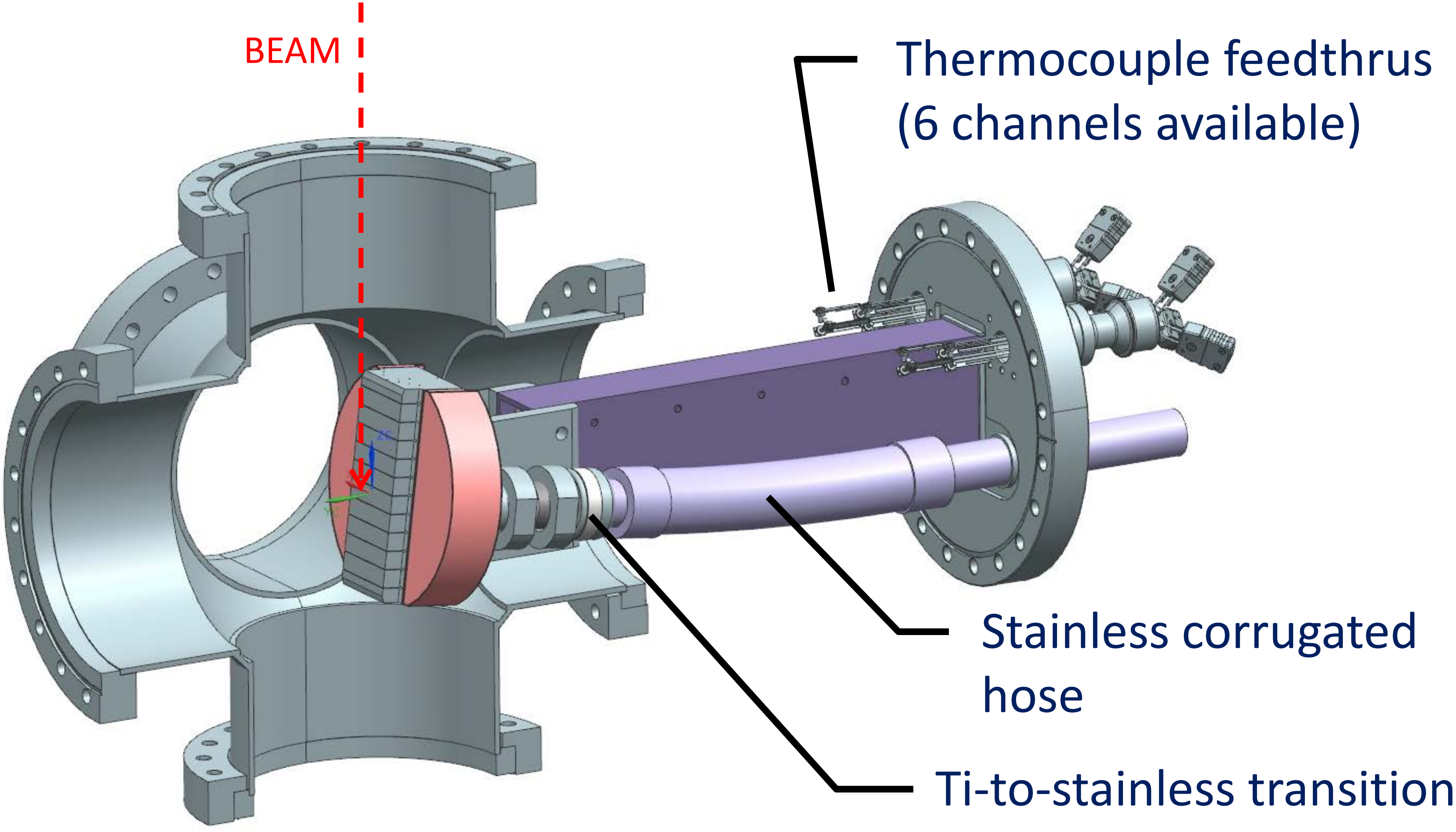
6 way cross provides interfaces for:

- Absorber mounting
- Pumping
- Diagnostics (beam profile, light generated at absorber surface)

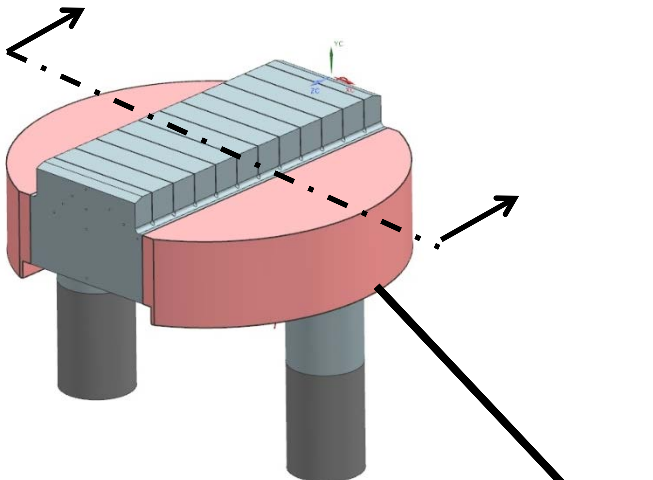
Manual adjustment of position and angle

Test Implementation: K. Carlson, B. Hanna, L. Prost, A. Shemyakin, J. Walton

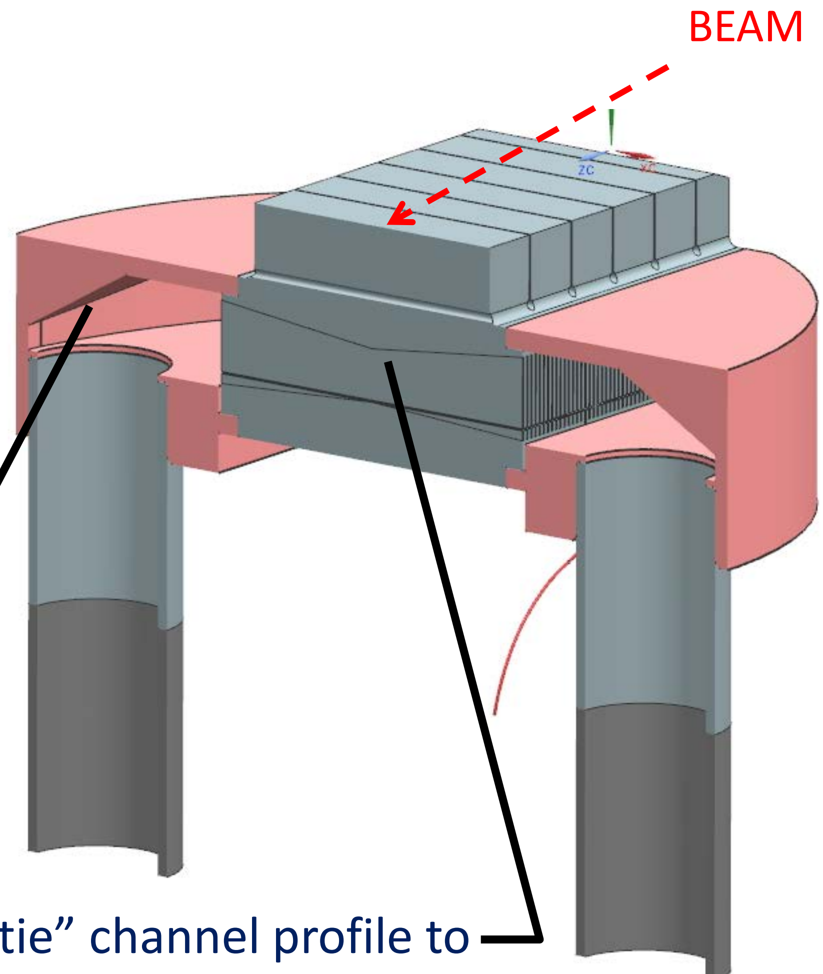
Prototype Absorber Assy



Prototype Module Geometry



Circular external shape to fit within commercial cross in e-Beam Test



Manifold profiling to control longitudinal (between channels) coolant velocity distribution

"Bowtie" channel profile to control transverse (within channel) velocity distribution

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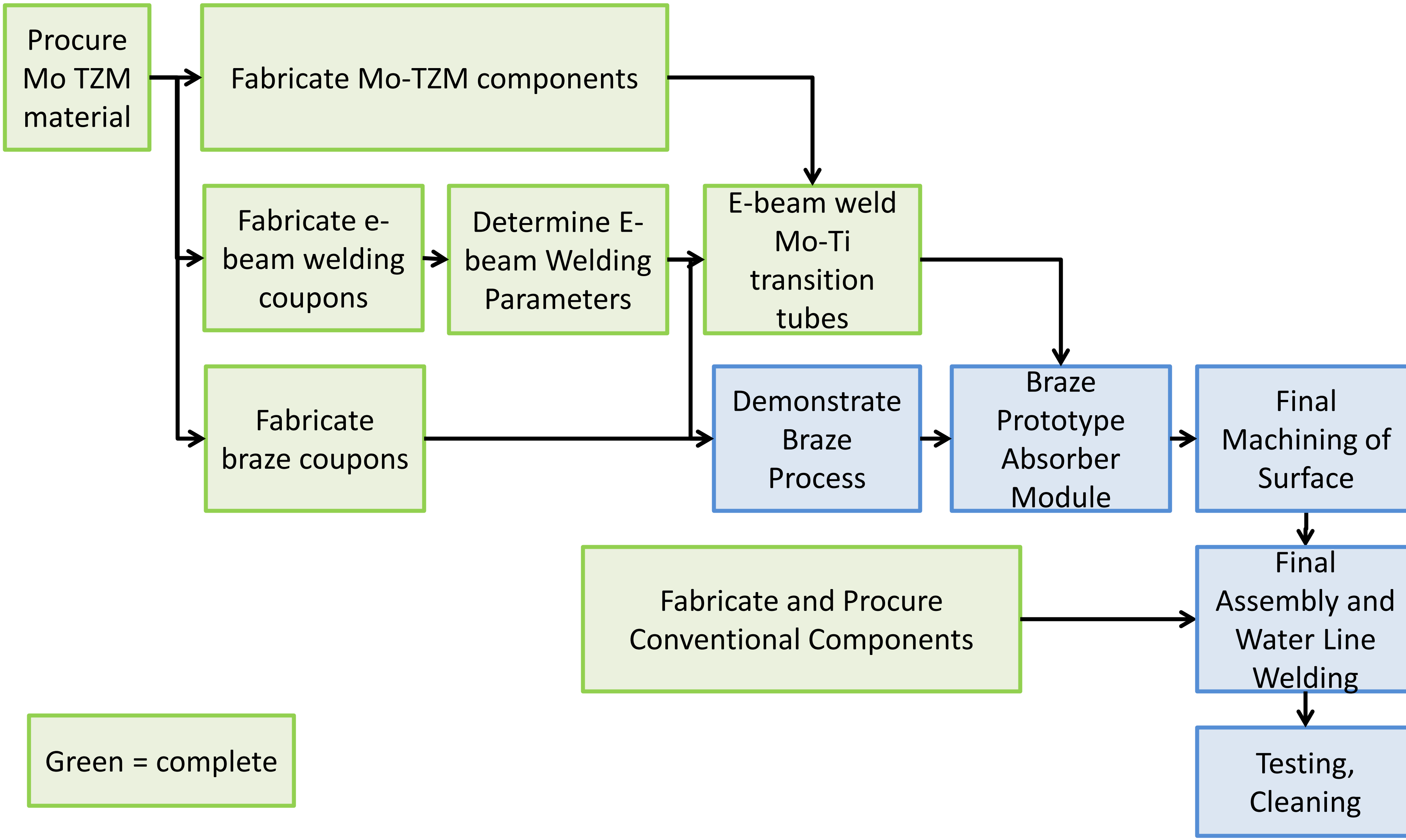
Module Fabrication Process



TZM Machining

Risks/Questions:

- Can complicated design be made without errors?
- Material is brittle at room temperature – can we work with it?
- Can cutting tools be used, or must all work be EDM?

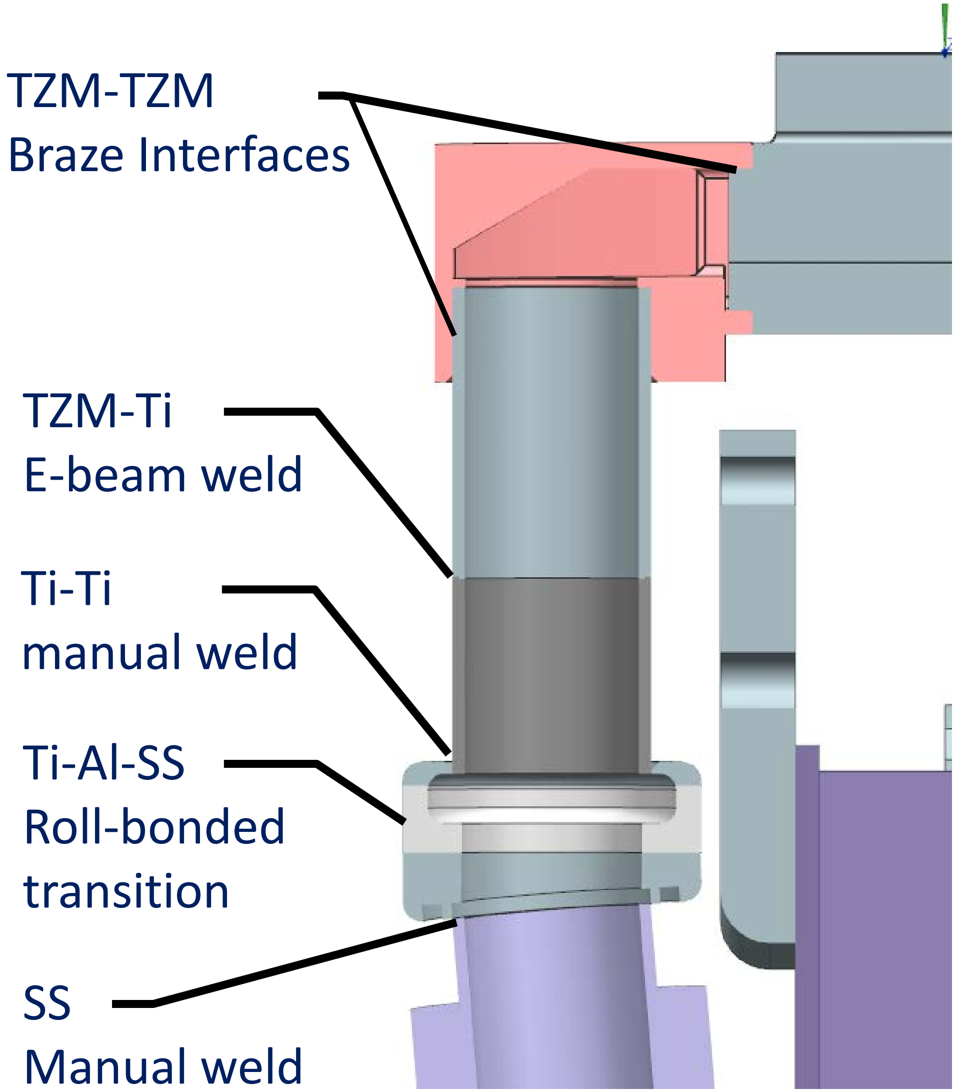
TZM Machining

Leak test of machined parts:
no misplaced cross-holes


Fracture of unpolished TZM tube

- Results/Lessons Learned:
  - Complicated TZM parts were machined without incident
  - Cutting tools were used, with a small and acceptable level of chipping
  - Electropolishing did not achieve desired level of surface smoothing – need to modify final machining steps
  - 1 of 6 unpolished TZM tubes fractured during pressure test preparation - perhaps we should polish all TZM parts

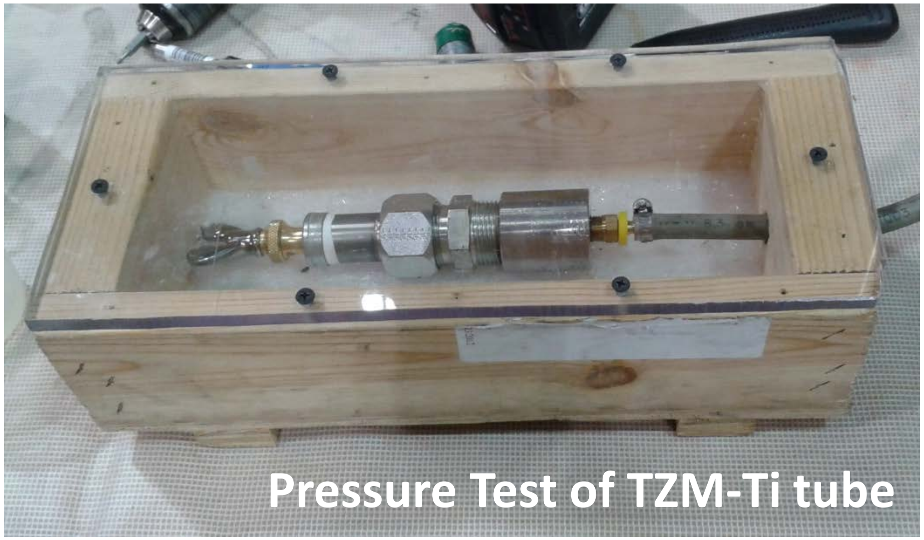
Joining Processes



- For the water circuit, we must connect TZM to itself and to stainless. Unfortunately, this requires numerous transitions

- Processes requiring development:
  - TZM to Ti e-beam weld
  - TZM to TZM braze joint

Joining Processes



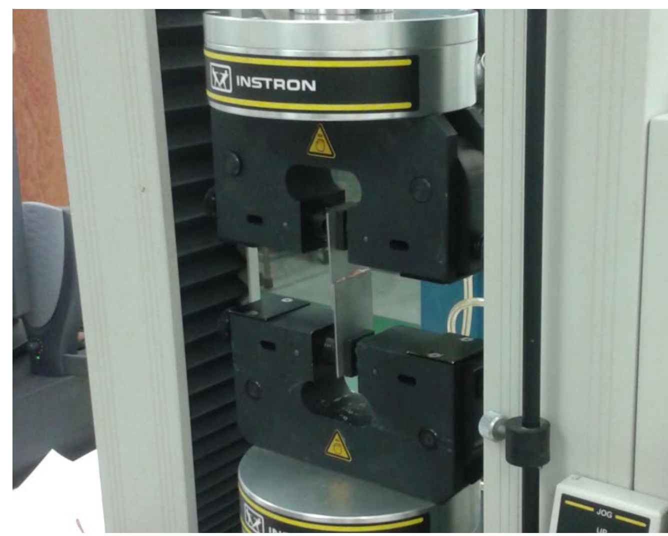
Pressure Test of TZM-Ti tube

TZM to Ti e-beam weld

- Process developed and implemented at vendor Sciaky
- Joints have undergone pressure testing, cycling to braze temperature, and helium leak checks

TZM to TZM braze joint

- Process development underway at vendor (California Brazing)
- Plan to attempt braze of prototype assembly late Nov.



Tensile Test of Braze Coupon

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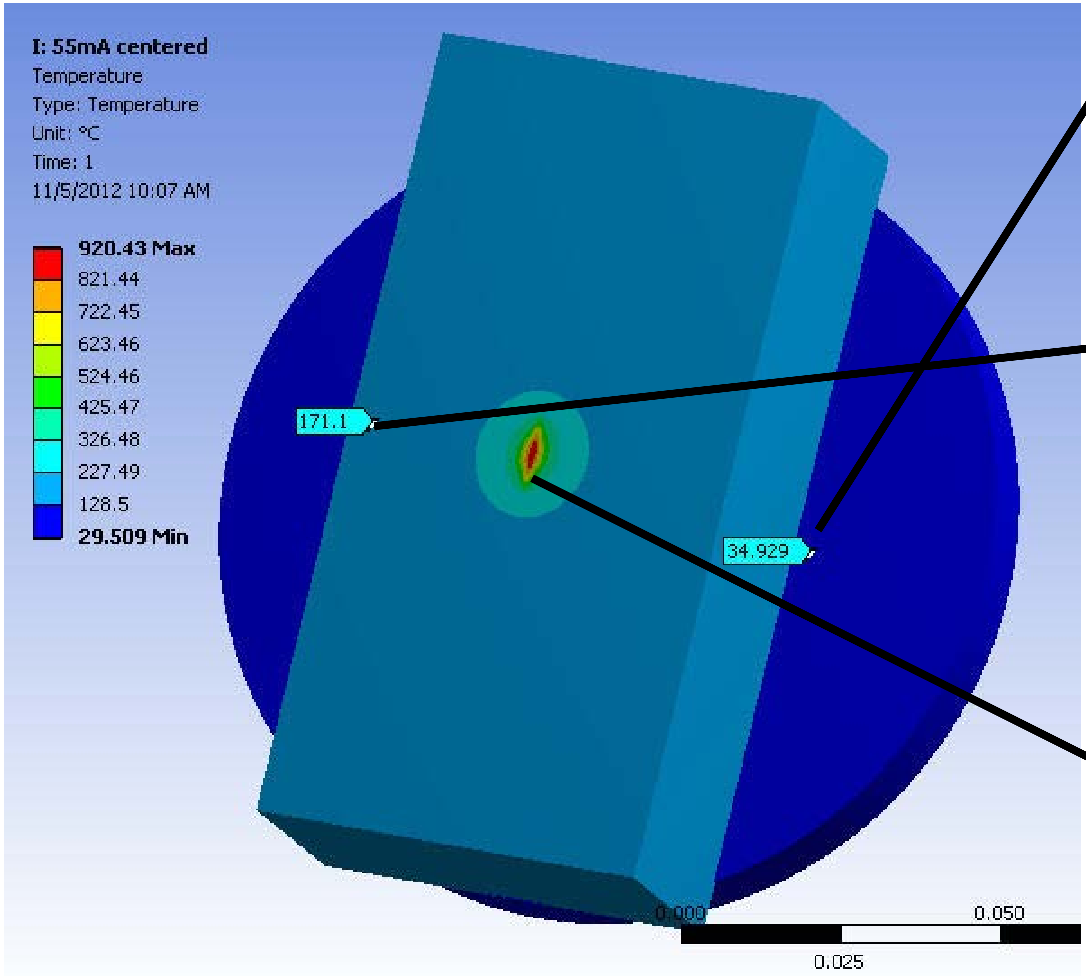
Next Steps

- Complete all TZM-TZM braze joints
  - This will include leak check and pressure test QA
- Complete final welding, assembly, QA, cleaning
- Complete commissioning of test bench
  - Occurring in parallel, see next presentation
- Refine testing plan based on capabilities of test bench
- Install and begin testing
- Correlate measured and predicted temperatures

Correlation Plans

- As beam approaches full power, beam size and intensity will be estimated optically
- Estimated beam parameters will be used to refine analytical temperature predictions
- Absorber temperature may be measured at multiple location by thermocouples. We have 6 feedthrus to work with, but can place the TCs in a wide variety of positions
- Actual temperatures will be used to refine the analysis model
- This process has been piloted using pre-prototype temperature data

Pre-Prototype
Analysis Sparse Correlation



- Convection Coefficient tuned to match Aluminum plate measured temperature
- AL-TZM thermal contact tuned to match TZM measured temperature
- Peak temperature of 920° consistent with observation of visible thermal emission

55mA X 28kV, 770 W absorbed, 3mm FWHM beam

Prototype Correlation
proposed initial TC locations